WHY SPACE SCIENCE AND EXPLORATION BENEFIT EVERYONE

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1. The Rationale - Knowledge, Discoveries, Motivation

Scientific inquiry into the nature of the universe beyond Earth and exploration of the Sun's solar system have to date been enterprises carried out primarily by the United States, the former Soviet Union, and only a few other industrialized states. Perhaps for this reason, their relevance to the issues that are the focus of the UNISPACE III Conference have not yet been given adequate attention or priority. This paper suggests why more attention is warranted and proposes several steps that might be recommended by UNISPACE III.

Clearly, the space science and exploration achievements of the last several years have captured the world's attention and interest. The people of Earth have shared the excitement of discovering and exploring the new worlds of our solar system and of looking beyond it into the cosmos; this is an an era that may prove as epochal as was the period of exploring the new worlds on Earth a half-millennium ago.

Perhaps the primary benefits of this new age of discovery are in their impact on humanity's appreciation of its own global habitat in the context of the solar system and the universe beyond. As Nandasiri Jasentuliyana, Director of the U.N. Office of Outer Space Affairs, has said: "the recognition that human beings are not the centre of the universe but are part of a greater natural order represented a dramatic change in people's attitude toward the world around them. *The new appreciation for the interdependence of human beings and their natural environment inspired a vast expansion of interest in, and study of, the natural environment, including other planets, stars, and the universe as a whole* [emphasis added]." But the benefits of scientific discovery are also quite tangible. As Jasentuliyana notes, "Basic science is a key to the prosperity of a nation, and it is almost impossible to expect significant economic and social development without a sound educational and research base in the field of basic space science." [Cf: **Space Policy**, "Viewpoint", p. 89ff, May 1995]

In the forty years of the space age, scores of new worlds have been transformed from barely discernable points of light to whole places with wonders and new discoveries; past life on Mars has been strongly suggested -- from indirect evidence showing it to have been warmer and wetter and maybe even from direct evidence in meteorites that were catapulted off the planet and landed here

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on Earth, millennia later. Of Jupiter's moons, Europa probably has an ocean of liquid water continually being heated by tidal forces, Ganymede has a magnetosphere, Io has continually acting volcanoes. Venus has a surface hot enough to melt lead while sulfuric acid and aerosols make its atmosphere equally hellish to imagine. Comets and asteroids bombard the planets and we now observe these bodies close up to see their composition and bizarre topography. In addition the peoples of Earth have been privy to stunning observations of galaxies colliding and being born at the edge of the universe, evidence of black holes, and discoveries of planets in other star systems. Space science and exploration truly reflect the popular *raison d'etre* for space programs. While other portions of the UNISPACE III agenda properly focus on tangible space benefits for humanity that can flow from the application of space technologies and capabilities, it is inappropriate to give only modest attention to that part of space activity that engages interest of the greatest number of people around the world.

The broad interest in recent discoveries should not be surprising. The nature of life in the universe intrigues everyone -- rich, poor, developed, developing. For all of human history, in all of human cultures, people have wondered about their place in the cosmos, the nature of planets and stars and their relation to Earth, whether they are alone, and the evolution of the universe, stars, planets and themselves. They have done this in their folklore, mythology, religion, culture and now humans can do it through science. Happily, that science is a complex and widespread task. The search for life in the universe (and indeed all aspects of planetary exploration and space science) require broad and multi-disciplinary approaches; there is room for all. Through widespread communication, instant availability of data and information, and the interest of especially children in exploration, space science and planetary exploration are becoming a world-wide participatory activities, not just elitist ones.

For these reasons, as we will argue in more detail below, the United Nations system and individual space faring nations of the world should give additional attention to the actions needed to make the benefits of, and indeed involvement in, space science and planetary exploration globally available to both the scientific community in developing countries and to the broader populations in those countries.

2. The Practical Benefits of Space Science and Planetary Exploration

The discoveries cited above, and many others, have given birth to new understandings in many sciences: physics, astronomy, geology, biology; environmental, ecological, engineering and computer sciences, to name some. But in addition to the intellectual benefits of new knowledge, the litany of significant mundane and specifically practical benefits is long, and has broadly touched the life of humanity. Let us consider a few:

- The runaway greenhouse on Venus, caused by an excess of carbon dioxide in its atmosphere has led to understanding of the dangers of carbon dioxide buildup on Earth and the resulting global climate change.

- The antiseptic surface of Mars, clean of any life or organic material because there is no ozone layer to protect it, provides a bleak description of what might happen if we destroy Earth's ozone layer.
- Finding aerosols in the atmosphere of Venus, and observing how they interact with the molecules there, has led to knowledge about what happens when we introduce aerosols into Earth's atmosphere.
- Observing and analyzing the dust storms on Mars have provided us with models of what happens to a planet's climate if massive amounts of dust are blown into the atmosphere, as would happen on Earth from a volcano, a large impact, or a nuclear holocaust.
- Asteroid and comet impacts on the terrestrial planets have profoundly influenced the evolution of those planets, and on Earth we now know that such impacts have wiped out species in the past and could again in the future.

Are these discoveries of interest only to a few? Hardly. All of them have important global significance to Earth.

3. Motivating Education and Scientific Literacy

Visit a village in South America or East Asia and you will find interest in the stars and planets. The discussion of them in a classroom motivates learning – especially in modern sciences and mathematics. Astronomy has long been a pace-setter in motivation and in application for education and development of scientific literacy. Ever since Galileo wrote *The Starry Messenger*, astronomy has been a means of communicating science and mathematics to the public, and a motivator for children to learn these subjects. In the twenty-first century world of information and technology, broad understanding of science, mathematics and technical subjects is crucial if the populace is to improve its quality of life. Through the World Wide Web, other internet services, the public media, satellite TV, educational and motivational programs, and telerobotics the findings of space science and planetary exploration will be available to all. They can catalyze learning. Assuming that the subjects of modern science are not relevant to a poor or illiterate population only assures they will stay that way.

Scientific illiteracy is one of the world's great problems and an increasingly divisive factor between haves and have-nots. Much of quality of living increase and economic growth now depends on scientific and technical awareness and on an ability to incorporate new knowledge and devices into the economy and lives of individuals. While learning about Jupiter's atmosphere does not necessarily contribute to income generation or solve economic problems, learning about the exploration of Jupiter pulls a whole educational experience along with it, motivating students and teachers to achieve in the modern world. Dealing with "brain drain" is a major challenge in many countries — young people are turning away from creative enterprises of high achievement because of lack of opportunity. Some bright young people interested in science and technology go to major industrialized countries to seek opportunity, but others are "turned off" by the lack of opportunity and follow less productive paths to simply make quick money. In the past, weapons technology was an area of opportunity in the United States and U.S.S.R. for creative engineering. Happily, the end of the Cold War is now

reducing the demand for new weapons. But the need for creative outlets for the human imagination is still there — and the opportunity for it to be exercised peacefully is now greater. Space work is not the only opportunity, but it is one of the best and certainly one of the most motivating.

The technology of exploration is crucial in this consideration. Communications, remote sensing, propulsion, electronics, information processing, and navigation are developments needed in all countries. If modern science and technology is not introduced into developing countries, continued poverty and depression is guaranteed. Of course, these and other technologies and engineering skills will be developed in far more widespread applications that space science – but the power of space science in the educational system to motivate their learning and inclusion cannot be overestimated! *The distinguishing factor of space science is the means by which it advances – Exploration. This captures public interest, and provides a vision, like little else in modern science and technology*

Large rockets are required to get to the planets (which is why only a few nations have conducted planetary missions). But participation in the missions through science instruments, interdisciplinary investigations, education and public information programs, engineering subsystems, high technology manufacturing, and innovation can all be done on a small scale as well as a large one. One or two scientists or a university group can make a substantive contribution bringing credit and interest throughout a whole country. Of perhaps greater potential is the redirection of military technology and expenditure to civil space applications, employing the same technical disciplines, applied to a problem of even greater motivation: the exploration of the universe.

4. Creating A Focus for Space Science, Solar System Exploration, and Developing Countries

The United Nations, and specifically its Committee on the Peaceful Uses of Outer Space and Office of Outer Space Affairs, could take the lead in involving both the scientific communities and the general populace of developing countries in the space science and planetary exploration enterprise. These bodies are the only institutions in which representatives of space faring and developing countries meet on a regular basis, and thus have a natural role in this area, once a decision to give it added emphasis is taken. In addition, these bodies already concern themselves with making sure the tangible benefits of space capability are made available to the developing world; extending this focus as proposed in this paper is quite consistent with this concern.. In fact, the United Nations has already taken important steps in this direction, most notably by convening a series of space science workshops around the world. Unfortunately, in our view, those workshops will not continue unless a decision to end them is reversed. But there is more that might be done, as is outlined below. In addition to its emphasis on space applications, the United Nations could develop programs of information and training, based on space science and planetary exploration results and activities, for those in developing countries wishing to increase their scientific literacy. Workshops or symposia for educators and others interested in the broader issues related to space science and planetary exploration could be convened under U.N. auspices. In addition, the United Nations could create a clearinghouse for both print and electronic information at various technical levels, using contributed funds to translate such material into various languages and creating a World Wide Web site for

information dissemination. Within the Office of Outer Space Affairs, one staff person could be assigned the "space science and exploration" portfolio, and serve as an advocate for a continuing U.N. role in this arena.

5. Restarting Space Science Workshops

Perhaps before undertaking any of these new initiatives, however, the United Nations ought to reexamine the recent decision not to continue the series of successful workshops in basic space science it has sponsored over the past seven years.[2] In 1991 the United Nations (UN) held its first UN Basic Space Science conference at India as a follow up to UNISPACE 1982. During UNISPACE 1982 the necessity to have workshops and conferences for developing countries in space science was identified. Hence, the UN Office of Outer Space Affairs developed the Basic Space Science conference program. The aim of the Basic Space Science conferences was to bridge the gap in space science between developed and developing countries. Later on that same year the First Space Conference of the Americas (Conferencia Espacial de las Americas) was held in San Jose, Costa Rica to stimulate collaboration in space science and space exploration among the Americas. During the educational session of this conference interest was expressed by many countries of the region to have workshops on space science. The Planetary Society (TPS), the U.N., and the European Space Agency were present at this conference and jointly decided to put space science conference together for this region. Costa Rica and Colombia both hosted the Second UN/ESA/TPS Basic Space Science conference. The theme of the conference included in the first week the solar system, planets, small bodies and planetary missions at San Jose, Costa Rica and the second week on astrophysics, radio astronomy and cosmology at Bogota, Colombia.

Since then the conferences have taken place on a yearly basis in different regions around the world, always concentrating on the needs of developing countries in space science. The conferences took place in 1992 in Costa Rica and Colombia, 1993 in Nigeria, 1994 in Egypt, 1995 in Sri Lanka, 1996 in Germany and 1997 in Honduras. The specific theme and focus of the conferences were defined by the hosting country and the interests of the region. But the common theme was space science and scientific collaboration. During the conference special attention was given to identifying areas of greater interest in space science as well as vehicles that would facilitate scientific collaboration. The conferences consisted of a combination of scientific presentations as well as workshops to identify the needs of the region with respect to mechanisms for cooperation. The findings of each conference were published in U.N. bulletins and in publications by the three principal

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[2]Prior to then, in 1987 The Planetary Society (TPS) developed a three week workshop at the Museo Tecnologico of Mexico City (ref. **The Planetary Report,** Jan/Feb 87 (p. 12-13)) in an effort to disseminate space science and space exploration to other countries. During this workshop world renowned experts in space science presented the latest advances and theories in the evolution of the solar system, planets ,comets, asteroids, origin of life and planetary missions. The workshop was attended by scientist and students from allover Mexico and special efforts were made to have lecture for the general public in Spanish.

organizational sponsors: (Ref. UN COPUOS reports 1992-96; Haubold, Ocampo, Torres and Wamsteker in the **ESA Bulletin,** no. 81, Feb. 1995; **The Planetary Report,** May/June 93 (p. 13-14), July/Aug 95 (p. 19), Sep/Oct 96 (p. 18)).

Ironically, as we prepare for UNISPACE III the conferences are being discontinued despite a strong desire among the participants to continue them. The UN COPUOS report (A/AC 105/657, 13 Dec. 1996) to the General Assembly stated that, "the participants strongly recommended that the United Nations should exert its best efforts to ensure that the . . . . workshops on basic space science continue in the years to come . . . such that the benefits . . .are optimally oriented toward young scientists in the various geographical regions." Within six months of this publication, the cancellation of the workshops was announced.

Following the enormously successful and inspiring **Mars Pathfinder** landing in July 1997, the African country of Mali honored one of its citizens who worked on that project (Dr. Cheick Diarra) and proposed to organize and host an African workshop on space science and exploration, building on the Mars exploration interest. This motivation is an example of what we describe above. Whether this workshop can be organized within the framework of the United Nations (COPUOS or UNESCO) is being investigated. The power of workshops to invigorate and educate a community, and to spread the benefits and knowledge of space science into the infrastructure of wider regions has been repeatedly demonstrated.

Besides the benefits to the region, we note additional benefits to the space science community from such interactions. The Planetary Society and ESA brought top scientists to these workshops. (Additional participation by NASA personnel is also acknowledged). They in turn brought new ideas and vitality in their work when they returned. The individuals involved have cited these benefits as the reason for their willingness to take time at no pay to continue to provide workshop faculty and expert support.

We also have considerable testimony from individuals in the countries and regions who participated in these workshops about benefits to their future careers and research. These are important – it is how we build indigenous infrastructure and develop a global community of participants. Thus the UN/ESA Basic Space Science Workshops for Developing Countries have been conducted for seven years and proved very successful in (a) promoting an infrastructure and interest in developing countries for space science, and (b) leading to specific space science projects for developing country participation. We recommend that a task force re-examine the decision to cancel them and consider their efficacy and cost, and the possibility of additional space agency funding to enable them.

6. The Potential Role of Non-Governmental Organizations as a Catalyst

While the main work of space development must come of course from national and international space agencies, non-governmental organizations (NGOs) can play an important catalytic role in partnership with governmental organizations in bringing together needs and capabilities from

different sectors of society. Operating with less formalism and constraints, and with more limited agendas, NGOs can serve both as advocates and as team-builders for international cooperation, both at the level of working scientists and at the level of the general populace. Certainly The Planetary Society played such a role in Mars programs, and with other planetary missions. But the real focus here is to suggest that NGOs serve as catalysts in education and public information. They can help bring together the powerful and considerable materials produced in NASA, ESA, RKA, NASDA and many other space agencies, the educational resources of international organizations such as COSPAR, ICSU, IAF, and the United Nations system, and the scientific professional organizations — with the larger public community of students and interested adults, educators, and organizations throughout the world who want to participate and want to receive the benefits of space science and exploration. Possible activities that could be undertaken by NGOs in partnership with the United Nations are described in the next two sections.

7. Educational Materials and Curricula

The United Nations is effective in distributing information, and providing communications for developing country scientists and educators who often do not have access to the products produced by the space agencies and in aerospace educational organizations. More and more, NASA, ESA and others are turning to the internet, and particularly the World Wide Web for their "outreach," as they are forced to reduce personal, material, printing, and mailing costs in their programs. But the Web is not really World Wide, and internet access is extremely limited in developing countries. Supplementary programs are needed. At least the material exists.

We propose a program of U.N. leadership and sponsorship to develop educational material capturing the latest information and results from space exploration. Such material should present a global outlook, and be designed to make the recipients feel that they are a part of space exploration and that space exploration is relevant to them. The support of national space and science agencies, educational organizations and NGOs for the development and distribution of these materials is crucial. The United Nations can and should mobilize and harness that support.

Printed materials are the main requirement – most of the world does not have ready access to electronic publications. But, electronic access – internet, World Wide Web, electronic mail, etc. is growing. Keeping in mind the philosophy cited above of not leaving developing countries out of modern approaches, we recommend that the U.N. distribution effort be both, and that specific programs to enlarge electronic access be encouraged.

The Planetary Society, hopefully with other NGOs, will work with the United Nations and with space agencies and international organizations to supply material -- printed and electronic. We immediately offer one poster depicting the latest discoveries and map of Mars (a new update of our enormously popular **Explorer's Guide to Mars**) and a subscription to The Planetary Report to any organization, school, or institution in the world who requests it and tells us they cannot afford our $25 membership fee, or $10 poster charge. We will also supply up to 1000 of these posters free of charge to any list of educational institutions provided by the United Nations (UNESCO or the Outer Space Affairs Division). {TO BE DISCUSSED AND APPROVED}

The Planetary Society is also conducting a world-wide contest to select student astronauts to teleoperate a nanorover on Mars in 2002, as we did with our world-wide international student contest,"Together to Mars," in 1990-92. The ability of such contests to attract global participation was demonstrated then. Thousands of students participated from scores of countries and winners represented a cross-section of global interest in planetary exploration. We will coordinate invitations to participate in this contest and subsequent student projects with the UN and other international organizations.

But beyond what individual organizations can do, a focused and coordinated program is needed to leverage individual efforts into truly global ones. There are many outstanding publications and materials available in the educational community, and from the space agencies. Help and money is needed in translating and packaging them for distribution, and for mailing and other distribution. But this could be done at relatively low cost.

Distribution in this program should be proportional to population in regions of the world, and should be just for developing countries. It is suggested that no organization contributing material be accepted unless they pay some costs of reproduction for global dissemination. Anything that can be done with the exciting materials from the space sciences will be a help in increasing education and awareness. If we can use this increase as part of an overall gain for scientific and technical literacy, we will contribute to economic and quality of life development in the world.

A spin-off from general education to public interest can be expected, again because of the traditional interest in space science discoveries and astronomical subjects. Public interest piqued by educational programs and by children's interest in space science will make space exploration programs more relevant to the general population. This should aid both the space program and the public.

8. Specific Projects and Technical Contributions

A number of specific projects can be cited concerning technical involvement of developing countries in basic space science. Particular for UN attention are the follow-up projects of the previously cited UN/ESA/TPS workshops:

- The Mars drill study in Egypt, with the cooperation of Russia and The Planetary Society;
- An observatory refurbishment in Egypt;
- Development of a telescope facility in Sri Lanka, Galactic Emission Map project in Colombia;
- An astronomical observatory in Honduras;
- An educational programs in Africa (including emphasis on computer literacy) and Central America.

In addition there are now satellites being developed in countries not hitherto among the space-faring nations. Argentina, Brazil, Korea, Israel, Korea, Thailand, Indonesia to mention a few. International programs among Latin American, Arab and Asian companies are also developing satellites. India

has long had an active space program and space science capability. There are astronomy projects and programs, and we can anticipate instrument and science participation in many countries. (Ref. UN annual reports, **Highlights in Space**, and preprint publications of the International Astronautical Federation, and of the Committee on Space Research (COSPAR)). COSPAR in particular has a Panel of Space Research in Developing Countries which publishes their findings (Ref. **Advances in Space Research**, Vol. 17, No. 8, 1996).

Some particular projects in space science that can be cited are:

- Argentina is the only country in the world providing a modicum of government support to the radio astronomical search for extraterrestrial intelligence (with operational support to provided to the META II project installed there by The Planetary Society).
- Participation by China in the ESA Cluster mission.
- India's participation in a gamma-ray telescope project of Russia's.
- Taiwan work in ionosonde and radar observations, and in solar and atmospheric physics;
- Argentina's SAC satellite development including the building of an X-ray spectrometer;

These enrich the space sciences, and they enable new ideas to be brought into consideration. In some cases, with the building of satellites, or spacecraft components, they permit costs by one country to be decreased, because of participation of others. In the long run that goal should be more and more realized.

Interested countries could provide expertise, and participation in missions and other space activities, not only with educational programs, but in contributing to and developing space mission data bases, instruments and components, particular co-investigators in scientific or engineering teams, and manufacturing or other production. It is recommended that a "announcement of opportunity" program be initiated by the major space agencies which informs a worldwide distribution list (to be developed by the UN and other international space organizations) of missions and technical programs whereby proposals for participation (probably on a non-reimbursable basis) can be invited. These would have to come early in the conceptual design – typically before a mission or program was approved. But the solicitation itself would be a form of global information and lead to encouraging new ideas and opportunities.

Another recommendation is that major projects and programs have a person assigned as international coordinator to solicit international contributions – from space-faring and non-space-faring nations alike. NASA has recently initiated the concept of a person designated as education coordinator on each project to encourage that form of outreach. An international coordinator could work similarly, hopefully with little expense to the project, and with the possibility for bring some potential cost-sharing.

9. Conclusions

We recognize that some of the recommendations here are idealistic and may even be counter-productive to other rules being set up in space projects, e.g. cost reductions, awarding work according to payment contributions, domestic work rules, reducing printed materials, etc. That does not lessen their value. It just means that compromises and changes will have to be sought. We have made the following recommendations herein:

- A reexamination of the Basic Space Science Workshops, seeking a way to continue and reinvigorate them;
- A staff person in the UN systematically gathering the material, and
- Contacting users to arrange for volunteer translation in the user country and UN supervision of the translation for quality control;
- Raising funds from agencies, industry companies, NGOs and international organizations to pay for large reproduction and printing amounts (e.g. with a target goal of ten million distribution at $0.50 (US) per copy per year;
- Development of a World Wide Web resource center, with extensive material that can be distributed over the internet or by print.
- An AO and International Coordinator process be initiated by major space-faring countries for encouraging international participation in space science missions.

We are a global community. In space as in science, collaboration is the means by which we can all benefit. Space has given us the reason and inspiration to aim for a global community. Science and technology can provide the means. But the critical ingredient that is independent of these factors is our willingness to see the best in each of ourselves and accept our weaknesses, not as an excuse not to go forward, but as a challenge to overcome them and go forward. We can no longer deny that the greatest feats that we as humans have achieved have always been built in the efforts of many for the benefit of all. This may be the noblest of reasons. The challenge is put forward, but are we ready to take it? We believe we are.